Sasol Chemicals
Sustainability &
Circularity

Position Paper - Life Cycle Assessment and Product Carbon Footprint

Version v 1.4, June 2024

Aim of this Document

The aim of this document is to support coherent application of Life Cycle Assessment (LCA) and the closely related calculation methodology for Product Carbon Footprint (PCF) data within Sasol. Hence, we will extend or update this document as necessary. It focusses on life cycle-related data intended for stakeholder communication. This document may be shared with external stakeholders when discussing methodological questions related to PCFs (see section Communication of PCF results).

Abbreviations

CCS	Carbon Capture and Storage (sometimes also referred to as CO_2 Capture and Storage)
CCU	Carbon Capture and Utilization (sometimes referred to as CO_2 Capture and Utilization)
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide equivalent
DB	Database
DU	Declared Unit
GHG	Greenhouse Gas
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
MLC	Managed LCA Content (Database by Sphera)
PCF	Product Carbon Footprint
PCR	Product Category Rules
TfS	Together for Sustainability

Background – LCA at Sasol

Sustainability is a key element of Sasol's strategy. One aspect of our sustainable development ambition is the quantification of the environmental impacts related to the production of our products. Life Cycle Assessment (LCA) currently represent the best science-based method to achieve the aforementioned.

The number of customer requests concerning LCA data has steadily increased over the last couple of years. Sasol understands that the data is required to enable our customers to conduct a meaningful analysis of their respective supply chains, which is why our teams are currently working on establishing a robust and reliable baseline for Sasol Chemical's entire product portfolio. We support these contributions by our customers to decrease their footprint and foster transparency.
The focus of the requests is clearly centred around climate impact. For the product-related assessment, we follow this focus. Therefore, this document is aiming at Product Carbon Footprints (PCF). Product Carbon Footprints follow the same method as LCA using only the impact category climate change during the phase of calculating the Life Cycle Impact Assessment (LCIA).
Significant progress has been made and high-level estimates have already been compiled for the most relevant products. These PCFs will be updated on a yearly basis while we work on expanding the coverage of PCFs towards our full product range. Selected PCFs have undergone a critical review. For the time being, increasing the coverage is prioritized over additional verification projects.

Guidance and Compliance

Life Cycle Assessment and the calculation of Product Carbon Footprints have long been standardized and the use of these standards is widely accepted. This section presents the standards and other guidance documents used at Sasol Chemicals.
Life Cycle Assessment is a method for assessing (potential) environmental impacts along the life cycle of a product from raw material extraction to the life cycle stage end-of-life. The system boundaries may be adapted. In a B2B context, they are oftentimes set to cradle-to-gate.
Product Carbon Footprints are a subset of Life Cycle Assessments. While the Life Cycle Impact Assessment is already set (and limited to) the category of climate change, the method otherwise follows the same approach. PCFs is currently by far the most-requested LCA-related information by our customers.
While ISO standards to calculate this data are well-accepted, their nature of covering the assessment of all possible products including services makes it necessary that they are shaped widely. They describe the general approach where the first phase, definition of goal and scope, is used to set up methodological decisions in order to meet the aim of the respective study. Therefore, the results for each subject of a study are highly dependent on the definition of goal and scope. This degree of freedom causes that following the norms does by no means guarantee comparability of results from different studies without assessing the underlying decisions and assumptions in detail.
Our work relies on the following global widely accepted guidance for LCA & PCF generation:

- ISO 14040/14044 (2006) - Environmental management - Life cycle assessment - Principles and framework/Requirements and guidelines
  These ISO documents describe the principles and framework for life cycle assessment including the definition of the goal and scope of the LCA, the life cycle inventory analysis phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for use of value choices and optional elements.
- ISO 14067 (14067) - Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification:
  This document specifies principles, requirements and guidelines for the

quantification and reporting of the carbon footprint of a product (PCF), in a manner consistent with ISO 14040 & 14044.

- Together for Sustainability (TfS) – Chapter 05: Specifications for Supplier's Product Carbon Footprint Calculation (2022)[1]:
The TfS Guideline (chapter 5) aims to provide methodological details for PCF calculations, where the ISO standards above lack it. The guideline provides specific calculation instructions for emissions from "cradle-to-gate" for chemicals, with the aim to harmonize PCF calculation approaches across the industry with applicability to the vast majority of chemical products.
- Additional Product Category Rules (PCR) may be used and are recommended by TfS Guideline to be used where relevant. If applicable, these choices are documented.

Sasol Chemicals is committed to align all new PCF studies with the detailed guidance that TfS provides and subsequently update all PCF information which already exist with the same principles in order to contribute to the availability of harmonized data throughout the chemical industry. We observe that the acceptance for these guidelines is high throughout the chemical industry. Through its strong membership structure, TfS may even be able to create acceptance among large customers in the chemical industry to become the standard for product carbon footprint calculation for all our suppliers in the near future. While we see the TfS Guidelines as an important step towards harmonization, they cannot guarantee comparability of the results yet (see also section Comparison of PCF results). Therefore, Sasol is committed to transparently communicate methodological choices together with PCF results.
In the following sections we will emphasize principles from the TfS guidelines in the context of PCF calculations at Sasol.

Goal and Scope

Sasol Chemicals is aligned with the goal and scope definition mentioned in the TfS guideline chapter 5.1. In all cases, a clear definition of the declared unit as basis for the PCF and system boundaries is included for disclosure. Subject to exceptions, the following applies:
System boundaries: cradle-to-gate
Declared unit (DU): 1 kg of product (at factory gate, unpackaged)
Unit of PCF: CO_2 equivalents (CO_2e)
Validity period: up to 5 years. More frequent updates are recommended and aimed for by Sasol. In any case, an update is required if impactful changes >20% PCF occur. Sasol will aim to revisit PCFs yearly in future, making minor updates as needed and gathering needs for bigger adjustments to feed these into the planning as tasks.

Data Sources

We follow an attributional approach in our work (and therefore also in our data and background data). For the foreground system (depicting the processes on-site) we are committed to using primary data which is obtained via colleagues who are involved with the relevant processes. This includes the production processes as well as on-site utility production and waste treatments where applicable. Bill of Material (BOM) data is in many cases used as a starting point from where it is discussed at which points additional or other information is needed. Additional information may e.g. come from measurements, process models, etc.. If possible, data should reflect the duration of one year in order to average out any seasonal fluctuations. The chosen period (e.g. the last completed financial year or the last completed calendar year) should then be used for all processes within the PCF project. There may be reasons to justify deviation from the chosen period for certain processes. Background data realizes the system boundaries cradle-to-gate. These consist of process inputs, such as raw materials, utilities and services. We actively engage our raw material suppliers to obtain reliable and up-to-date datasets for use within our models. If a supplier can provide adequate supporting evidence, we will use his data as primary data input. As of now, the availability of PCF information from suppliers is scarce. The remaining data is obtained following the following data hierarchy:

1. Reliable Supplier information
2. Managed LCA Content (MLC) database by Sphera (if available at Sasol)
3. Use of literature data including other databasess (e.g. ecoinvent)
4. Use of high-level estimation to close data gaps.

Sasol holds licenses for the MLC Database by Sphera, several Sphera extension databases and the ecoinvent database. All of these licenses include yearly updates. In some cases, several datasets are available for a material. The following aspects should be taken into account for making the choice:

- If technology from the supplier is known, select corresponding dataset
- If the region/country is known, select the technology/energy mix which dominates that region
- Otherwise select the world-wide market average
- If all not available, select the process with the highest PCF (worst-case)

If it is necessary to use ecoinvent datasets, the system model “cut-off” shall be chosen as this is closest to the modelling principles applied by Sphera to produce the MLC databases (and extensions). If literature data is used, it should be ensured that an attributional approach (as opposed to consequential LCA) is chosen.
If it is necessary to pass level 2 of this hierarchy to realize the system boundaries and information obtained via level 3 to 4 is included in the PCF model, this needs to be subject for discussions about the impact of this to the overall results (see section Quality of PCF).
LCA practitioners are responsible to critically assess whether the applied datasets are appropriate with regards to data quality (including i.a. technological, geographical and temporal representativeness) and report their choices by indicating the specific datasets used including the date or version of the source.

Multifunctionality

Multifunctionality is omnipresent in our processes. Due to its importance for PCF results, our approach is described here. TfS refers to Multi-output processes when a process delivers more than one product. These co-products can also include energy products (such as steam or electricity, or any other product with a defined economic value such as a residual fuel).

To support the decision on how to attribute inputs and emissions in multi-output situations, you can find a table in the annex that gives some examples. To solve a multi-output situation in line with the ISO standards (14067 and 14040/44), the following hierarchy shall be applied to attribute impacts for multi-output processes:

1. Process subdivision
2. System expansion and substitution
3. Allocation

This hierarchy belongs to an attributional LCA approach, which we follow (as opposed to a consequential approach).

Sasol Germany GmbH
Anckelmannsplatz 1, 20537 Hamburg Postal address: Postfach 26 18 05, 20508 Hamburg
Telephone: +49 40 63 684-1000 Telefax: +49 40 63 684-3700 info@de.sasol.com www.sasolgermany.de

Managing Directors: Dr.-Ing. Thomas Tebroke Chairman of the Supervisory Board: Christian Schindler
Registered Office: Hamburg Register Court: Amtsgericht Hamburg HRB 78475

Process subdivision
We aim to avoid allocation wherever possible as required by ISO standards. When it is possible to divide a seemingly multifunctional process by assessing it on a more detailed level, this is called process subdivision.

System expansion and substitution
If subdivision is not possible and there is a dominant, identifiable substitute product for a by-product, this can be used for system expansion and substitution. This approach is sometimes referred to as giving "credit". In any case, it is crucial that the data used for the substitution is chosen very carefully. The impact on the overall result should be shown clearly with the results.

Through these constraints, substitution does not make sense in many cases for Sasol Chemicals. The following aspects limit the cases where it would be feasible to apply substitution at all.

- Substitution can be used if the process is operated to produce a main product (which is the subject of the PCF calculation) and the co-products are unavoidable but not desired by-products. This is hardly the case for our production processes.
- A dominant, identifiable displaced product and production path for the displaced product based on sector consensus is needed for the approach. In addition, data for this replacement would need to be available. In many cases, there is no such clearly identifiable single product available. If there is, it is almost certainly coming with its own multi-output challenges which would then need to be also solved.
- Substitution shall only be applied to a co-product which must not be the main product. We aim for full coverage of our product range, including products which at some point during the production process have been considered a by-product. We receive PCF requests for these as well.
- Allocation aligns better with Corporate Carbon Footprint reporting.

Therefore, for on-site multi-output situations we choose the coherent application of allocation (see section Allocation). System expansion and substitution may be applied to the system boundary "at gate", which is mostly used for energy products where a credit is given for replaced fuels.

Allocation
Due to the complexity of many of our production sites, Sasol Chemicals has decided to consistently apply allocation based on physical relationships as the default option. Allocation is defined in ISO 14044 as "partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems".

If Hydrogen is a coproduct, the physical allocation shall be applied on heating value basis according to TfS (see note in the PCR section for steam crackers). Unit types other than mass may be used for physical allocation depending on the production system and the products produced.

TfS suggests using economic allocation if the ratio between the value of the main and by-product(s) is higher than five. Co-products that have a small share (<= 1 % in mass or volume) can be skipped in the decision about the allocation method. Obviously, economic allocation can only be applied, if there is enough economic data available to support a uniform application through the system in question. If economic allocation is used, the implications of this step should be discussed, including the inherent violation of the mass balance.

For utilities that are produced onsite via assets producing more than one form of energy, the so-called efficiency approach (as described by GHG protocol[2]) is applied to consider the

Sasol Germany GmbH
Anckelmannsplatz 1, 20537 Hamburg Postal address: Postfach 26 18 05, 20508 Hamburg
Telephone: +49 40 63 684-1000 Telefax: +49 40 63 684-3700 info@de.sasol.com www.sasolgermany.de

different qualities of these energies in a feasible way. An energy balance of the complete utility system is needed for that. Energy recovery on site is subsequently accounted for via substitution/credits using the marginal (replaced) form of energy. The calculated emission factors for the utilities can be used to attribute credits for on-site generated steam/thermal energy to the specific units producing them.
Note: This may have a negative impact on the footprint of certain products when greening the utilities as the credits become lower.

PCRs

The TfS guidelines include PCRs in their decision tree for the approach towards multifunctionality (see TfS guidelines, Figure 5.16). Within the hierarchy named above, use of PCR is placed between 'system expansion and substitution' and 'allocation'. However, TfS also states with regards to system boundaries that "[w]here PCF Product category rules (PCR) are used, their requirements on the processes to be included supersede those indicated above" (TfS guidelines 5.1.2). Due to this importance that is rightfully given to existing PCRs, existing PCRs should be researched during definition of goal and scope and their implication on any methodological choices should be made clear. When it comes to dealing with multifunctionality, if the PCR gives specific requirements, for any valid PCRs these also follow the ISO hierarchy.

TfS includes a list of PCRs accepted by them (table 5.2). The list, which can serve as a starting point for applicable PCRs, includes amongst others the report from the ERASM[3] project that should be considered for C12-14 alcohols (oleo), methyl esters, refined and crude oils from oil palm and coconut. If a steam cracker is part of the product system, the recommendations by Plastics Europe Steam Cracker allocation[4] should be used.
Note: While TfS includes the Plastics Europe Steam Cracker allocation explicitly as an accepted PCR, this rationale contradicts the statement of the TfS guidelines with regard to how Hydrogen is handled: Within the PCR, impact shall be allocated via mass. Following the TfS Guidelines would mean using this PCR while at the same time, the TfS guidelines state that if Hydrogen is a coproduct, allocation via heating value shall be applied. The implication of this should be discussed by doing a sensitivity analysis about this allocation decision.

Recycling

The impact of material recycling (e.g., chemical recycling, distillation of materials, mechanical recycling) is to be included in the product lifecycle inventory and system boundary. If material recycling happens within the product system boundaries, the impact is automatically included in the PCF of the product. If material recycling happens outside of the product system boundaries, the Cut-off approach shall be applied. Meaning, in the recycling process, the waste input is considered to be burden-free. One should be aware that this methodological choice impacts the results towards rewarding the use of recycled materials.

Waste treatment

A waste is any substance or object which the holder discards or intends to discard. Since waste is considered an output without economic value, no production emissions are attributed to the actual waste generated during production. Emissions from the treatment of non-recycled waste generated during production to be allocated to the main product and/or co-products and reflected in their PCF. The GHG emissions calculation from wastewater treatment shall include the emissions coming from the biological degradation as well as the emissions from the operation of the wastewater treatment plant and the disposal of the sludge (incineration etc.).

If possible, primary data for waste treatment (including wastewater treatment) or a specific dataset from a LCI-DB (secondary data) shall be used.
For waste treatment with energy recovery within the product system boundaries, the impact of incineration to be included in the PCF of the product, while the recycled energy is part of the system utilities model for the site. For waste treatment with energy recovery outside of the product system boundaries, the substitution approach is in favour, documenting the dataset used for substitution. The dataset should consider the regional energy system and what is most likely to be avoided by supplying the energy (e.g. regional electricity mix or fossil fuel saved). The difference in energy systems causes that different datasets are chosen for substitution depending on location.

In the case that an estimation is necessary for the emissions related to waste treatment (due to lack of primary and secondary data) the Total Organic Carbon (TOC) load of the waste materials can be used as a basis for calculations. In this case, it should be assessed whether methane formation is likely to occur or to be negligible and taken into account accordingly.

Biogenic Content, Uptake and Emissions

According to TfS, biogenic uptake shall be included in the LCI. Also, emissions of biogenic Carbon (e.g. as carbon dioxide or methane) shall be modelled. For PCFs with the system boundaries 'cradle-to-gate' this may cause the reported Product Carbon Footprint of biobased materials to be negative. From 2025, the biogenic carbon content shall be part of the information to be reported with the PCF.

In general, carbon atom based allocation for biobased materials has many benefits and prevents the need to apply corrections (as described below). While the default option for allocation within our models is physical allocation, there may be cases where economic allocation has been applied along the value chain. As economic allocation violates mass balance, this would cause misleading results especially when considering the full life cycle of a product. TfS therefore advises adjusting for this:
'In some cases, e.g. when allocation is applied, the carbon flows might not represent physical reality in terms of C-content. To avoid misleading or incorrect calculations, a carbon correction shall be applied at the end of the PCF calculations. It must be ensured that the biogenic carbon content in the product is equal to the sum of biogenic removal of CO_2 and biogenic emissions of CO_2 and methane. If this is not the case (e.g. because of allocation somewhere along the value chain) then the value of the biogenic CO_2 removal shall be adjusted.' (TfS Guideline, 5.2.10.1)
This adjustment (via carbon counting) needs to be made for all material streams including biogenic carbon atoms, which means that the product is attributed to include the biogenic CO_2 removal which corresponds to the carbon content it has. TfS plans to further extend their guidance on biogenic emission and removals in the future.
In case of recycled materials that include biogenic carbon, these do not get attributed the benefits of biogenic carbon as the material enters the system burden-free.

As we follow an attributional approach, the impacts of land use and direct land use changes on PCFs are included while indirect land use change is not included.

Note: There is still a lack of alignment for handling biogenic materials in LCA. We follow the methodological development and aim to update this section accordingly.

Sasol Germany GmbH
Anckelmannsplatz 1, 20537 Hamburg Postal address: Postfach 26 18 05, 20508 Hamburg
Telephone: +49 40 63 684-1000 Telefax: +49 40 63 684-3700 info@de.sasol.com www.sasolgermany.de

CCS, CCU, DAC

A lot of methodological development is taking place on how to account for these technologies in LCA. We will monitor upcoming guidance in order to put it into practice when these technologies become relevant for Sasol products.

Quality of PCF

In order to ensure the quality of the PCF results, PCF calculations at Sasol are accompanied by several stakeholder meetings and detailed discussions between the LCA practitioners and colleagues with in-depth knowledge of the respective processes. During this process, emphasis is put on the following points:

- mass balance check
- stochiometric balance check
- review of allocation factors and calculation formulas
- plausibility check of utility consumption
- check if direct emissions are realistic, e.g., by carbon balance
- appropriateness of secondary datasets based on geography and technology
- sensitivity of results caused by data from different sources than the MLC DB and the Sphera extensions

From 2025 a data quality rating (with a range from 1-3) needs to be part of the information communicated with PCF results. This is not implemented in our reporting yet.

Communication of PCF results

Sasol is committed to sharing data along the supply chain. PCF data ranges can be shared based on product groupings without a non-disclosure agreement. For more details or product specific details, a unilateral Sasol standardized non-disclosure agreement will need to be in place. To communicate the PCF results for Sasol's products in a coherent manner, Sasol Chemicals has developed a standardized LCA factsheet, which will be used going forward. When harmonized platforms/data transfer protocols widely accepted across the Chemical industry become available soon, Sasol Chemicals will consider communicating PCF results via those.

Comparison of PCF results

While we value the work of TfS to streamline the PCF methodology across the chemical industry, we understand that results are not yet directly comparable. E.g., the choice of the LCI background database or the assumptions about systems expansion might cause differences in the PCF results while both results would comply with the TfS guidelines. Therefore, we treat requests for PCF data as an invitation for a discussion. We will provide supporting information (while protecting sensitive information).
Following through on this, we advise colleagues who are responsible for purchasing raw materials to request PCF information while encouraging open discussions with our suppliers about the underlying data and methodological choices.

Sasol Germany GmbH
Anckelmannsplatz 1, 20537 Hamburg Postal address: Postfach 26 18 05, 20508 Hamburg
Telephone: +49 40 63 684-1000 Telefax: +49 40 63 684-3700 info@de.sasol.com www.sasolgermany.de